energy of the magnets can flow.

[0004] This thick wire has a high rigidity, so that it requires a large tensile force to wind the wire around a magnetic pole tooth to form a coil. Thus, a large pressing force corresponding to the tensile force is exerted on coil end surfaces of the magnetic pole tooth. A method and apparatus for forming such windings is disclosed in the application entitled "WINDING METHOD AND DEVICE FOR AN ARMATURE FOR ROTARY ELECTRIC MACHINES", Serial Number 10/064,923, filed concurrently herewith by the assignee hereof, based upon Japanese Application Serial Number 2001-271207, Filed September 7, 2001.

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[0005] Although the method and apparatus described in that copending application is very effective in providing the coil winding, still further improvements can be made. For example, a large stress is applied to edges of the coil end surfaces, namely, edges of the magnetic pole tooth, against which the wire is bent and pressed. This problem can be particularly difficult in connection with the insulating material around which the wire is coiled. This may be understood best by reference to FIGS. 1 through 4. As noted below, these figures are, respectively, a top plan view of the one half of insulating material, a cross section taken along the line 2-2 of FIG. 1, a bottom plan view of the insulator half and a cross sectional view taken along the line 4-4 of FIG. 3.

[0006] The insulating material is made up of two halves only one of which is shown and which is indicated generally by the reference numeral 21. Basically it has a configuration complimentary to the armature core. This is comprised of a central portion 22 that has an opening 23 for passing the shaft of the associated armature. Radially extending teeth 24, which are complimentary to the armature teeth, extend outwardly and have a generally U-shaped configuration as shown in the cross sectional views of FIGS. 2 and 4. Generally the insulator 21 is quite thin, having a thickness of only about 0.5 mm.

[0007] This shape is comprised of individual side portions 25 that face the sides of the armature teeth and which are joined by an integral bridging portion 26 that extends generally in an axial direction relative to the axis of rotation of the machine. As a result, curved edge portions 27 result which are actually thinner than the thickness of the portions 25 and 26 and may be damaged due to the high pressure and loading

from a neodymium type material that provides a high energy permanent magnet.

[0024] The housing 52 is completed by means of a front end cap 56 and rear end cap 57 that are affixed in any suitable manner to the ends of the yoke shell 54 to define an enclosed space in which a rotor in the form of an armature, indicated generally by the reference numeral 58 is journal led. The rear end cap 57 is formed with a mounting bracket 59 so as to permit attachment to the body of the associated engine.

[0025] The rotor or armature 58 is comprised of an armature shaft 61, the forward end of which carries a starter gear 62 for associated with the starter gear on the flywheel of the associated internal combustion engine. The end cap 57 has a projecting end in which an O-ring seal 63 is received so as to provide a good seal around the starter gear. This end of the armature shaft 61 is journaled in the end cap 57 by an anti-friction bearing 64. An oil seal 65 is disposed immediately to the rear of the bearing 64. In a like manner, the rear end of the armature shaft 61 is journaled in an anti-friction bearing 66 carried by the end cap 57.

[0026] The armature 58 is comprised of a core, indicated generally by the reference numeral 67, and which has a construction as best shown in FIG. 6. This is comprised of a laminated core having a plurality of radially extending pole teeth 68 which have enlarged head portions 69. These pole teeth 68 are circumferentially spaced from each other to define slots 71 therebetween. The enlarged head portions 69 leave a narrow mouth 72 therebetween opening into the slots 71.

[0027] Although not shown in details in FIGS. 5 through 7, individual coil windings are formed around the pole teeth 68 preferably in the manner described in the aforenoted co-pending Application No. 10/064,923, based upon Japanese Application No. 2001-271207. The ends of these windings are connected, in a manner as described in the aforenoted co-pending application, to a commutator, indicated generally by the reference numeral 73 and specifically to the contact strips 74 thereof.

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[0028] As best seen in FIG. 7, brushes 75 are carried by brush carriers 76 mounted on a commutator plate or brush holder 77. These brushes 75 are urged into engagement with the commutator strips 74 by springs 78.

[0029] The electrical current for energizing the windings is delivered through a terminal